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Aggregate Resources Inventory of Cavan, North Monaghan and South Monaghan Townships Peterborough County Southern Ontario

By Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

1985

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources and the Ministry of Northern Affairs and Mines do not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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Aggregate Resources Inventory of Cavan, North Monaghan and South Monaghan Townships Peterborough County

by Staff[1] of the Engineering and Terrain Geology Section

1. Project Supervisors: Dale W. Scott and I. Szoke; field work and report by G. Jones; compilation and drafting by Staff of the Aggregate Assessment Office. The Mineral Resources Staff of Lindsay District and Central Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

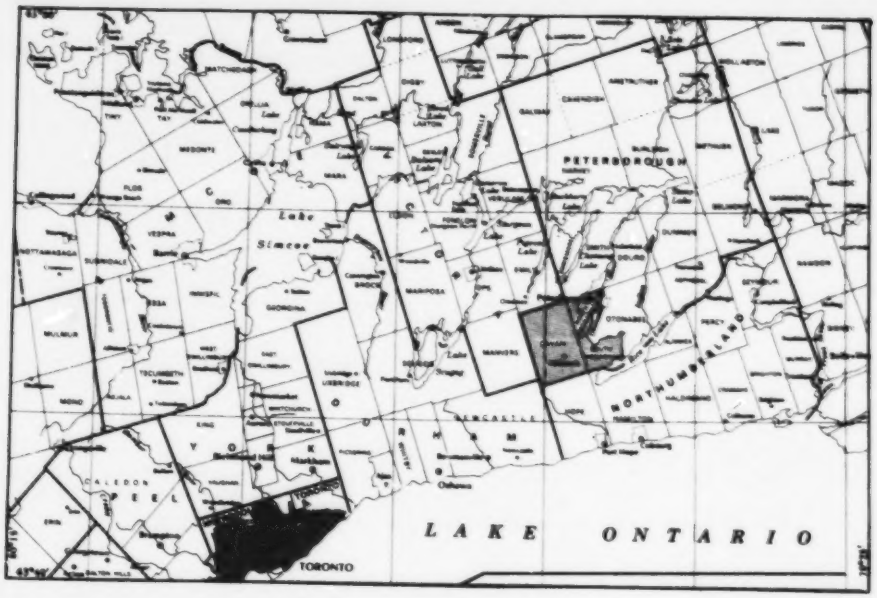


Figure 1. Key map showing the Location of Cavan, North Monaghan and South Monaghan Townships, Scale 1:1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in Cavan, North Monaghan and South Monaghan Townships. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Pits and Quarries Control Act.

Within the three townships, four areas consisting of ice-contact, esker, kame and outwash deposits have been selected for possible resource protection at the primary level of significance. These Selected Resource Areas occupy 1500 acres (610 ha), exclusive of licenced properties. An estimated 1180 acres (480 ha) are currently available for extraction, containing resources of approximately 58 million tons (53 million tonnes). The parts of the selected areas which are available for extraction represent 3 percent of the total area occupied by sand and gravel deposits in the townships and 4 percent of the original resource tonnage.

Several ice-contact deposits have also been selected as resources of secondary significance. These deposits add considerably to the resource base of the townships and should be considered an important part of the area's aggregate supply.

The aggregate resources in the study area are generally of excellent quality and suitable for the production of a wide variety of construction and road-building products. The main factor controlling the suitability of the aggregate is the excessive sandy nature of some of the deposits which can restrict high-specification use of the material. Generally, the report area contains resources which should supply local needs for a considerable period of time. Most of these resources are concentrated in Cavan Township. North and South Monaghan Townships contain only limited aggregate resources.

The surficial deposits in the report area are underlain by bedrock of the Verulam and Lindsay Formations. Although these formations are generally suited for lime production, no areas have been selected for possible resource protection as the bedrock is usually covered by excessive drift thickness.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregates extracted was 101 million tons (92 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1983).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential of bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing, hand augering and geophysical techniques are used to assess subsurface materials. Airphotos at various scales are used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100-pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution and in some cases Los Angeles abrasion, absorption, and Magnesium Sulphate soundness tests along with petrographic analyses are performed.

Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey. In areas of limited subsurface exposure, test holes are drilled and geophysical surveys using hammer seismic equipment are undertaken. The symbols for and locations of sample and test hole sites along with geophysical traverse lines are noted on Map 1.

In the office, the field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography

maps, and from the interpretation of water well records. The measured exient of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tons of a one-foot (0. 3 m) thick section of rock, one acre (0.4 ha) in extent).

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg per cubic metre) or 3600 tons per acre (8070 tonnes per hectare). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

Part II — Data Presentation and Interpretation

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

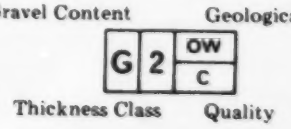
Map 1 is derived from existing surficial geology maps of the area or from airphoto interpretation in areas where surficial mapping is incomplete. The map shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, all sand and gravel deposits are outlined and shaded. The present level of extractive activity is also indicated. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The information from which these symbols are derived has been plotted in grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol. Geophysics lines are shown on the map by a line symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by dark shading on Map 2.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light shading on Map 2. Such deposits are believed

to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the litholgy of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes, pits or sample sites have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the

basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalites with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three levels of shading. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas consitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource ares. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected drill hole which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting

criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approch. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Part III — Assessment of Aggregate Resources in Cavan, North Monaghan and South Monaghan Townships

LOCATION AND POPULATION

Cavan, North Monaghan and South Monaghan Townships occupy areas of 65,215 acres (26 392 ha), 9612 acres (3890 ha) and 19,501 acres (7892 ha), respectively, in the southwestern part of the County of Peterborough. North Monaghan and South Monaghan Townships are situated west of the Otonabee River and Cavan Township borders their western boundary. The study area is shown on parts of the Lindsay (31 D/7), Peterborough (31 D/8), Rice Lake (31 D/1) and Scugog (31 D/2) map sheets of the National Topographic System at a scale of 1:50 000.

The population of the report area was 6143 in 1982, an increase of approximately 30 percent since 1972 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The City of Peterborough is the major population centre in the area, and borders the northeastern part of North Monaghan Township. The Village of Millbrook is found in the central part of Cavan Township. Peterborough's population was 61 595 in 1982, while Millbrook's was 940 (Ontario Ministry of Municipal Affairs and Housing 1983). The majority of the residents in the townships are engaged in farming or are rural-residential inhabitants. There is also a large recreational population along the shore of Rice Lake in the southeastern corner of South Monaghan Township.

Access within the townships is provided by gravel surfaced township roads, paved county roads and King's Highways 7, 7A, 28 and 115. The study area is also served by a line of the Canadian Pacific Railway.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including sand and gravel deposits, are the result of glacial activity which took place during the Late Wisconsinan Substage of the Pleistocene Epoch, informally known as the "Great Ice Age'. This substage, which lasted from approximately 23 000 to 10 000 years ago, was marked by the repeated advance and melting back of massive, continental ice sheets.

During the Late Wisconsinan, the report area was covered by an oscillating lobe of the continental ice sheet which advanced in a southerly direction out of the Lake Simcoe basin. Another lobe advanced in a northerly direction out of the Lake Ontario basin to a position near the southern boundary of the report area (Gravenor 1957). These lobes were confluent or in close proximity to each other during much of Late Wisconsinan time. During periodic warming trends, large quantities of meltwater flowed away from the ice margins, depositing sediments between the lobes and forming a broad hummocky ridge. This ridge is referred to as the Oak Ridges Moraine and is a prominent glacial feature in southern Ontario (Chapman and Putnam 1984).

The moraine can be observed in the southern part of Cavan Township where a maximum elevation of approximately 1100 feet (335 m) above sea level (a.s.l.) is reached. The moraine is a complex feature which has been influenced by several episodes of sand and gravel, and till deposition. In Cavan Township, sand is the predominant sediment exposed in the moraine although concentrations of gravel and silt occur locally. Several pits have been developed in the moraine and it has been a traditional aggregate source in the report area.

The final advance of the Lake Simcoe lobe deposited large amounts of stony, sandy till forming an extensive till plain in Peterborough County (Gravenor 1957). This till plain is characterized by numerous drumlins and has been referred to as the Peterborough Drumlin Field (Chapman and Putnam 1984). The drumlins are streamlined, elongated hills which are oriented in a northeast-southwest direction. The drumlins occasionally contain pockets of stratified sand and gravel which have been extracted for local use in the report area.

During the final advance of the Lake Simcoe lobe, the ice overrode the northern flank of the Oak Ridges Moraine. Isolated bodies of till exist on the surface of the ridge and till covers a considerable amount of ice-contact sand and gravel along the moraine's northern flank. North of the moraine, where valleys have cut through this till cover, ice-contact stratified drift is often exposed along the valley sides. Where the till has not been completely removed, buried ice-contact deposits occur. A number of these ice-contact deposits have been extensively used as aggregate sources.

The deglaciation of most of Peterborough County occurred by the melting-in-place or "stagnation" of the ice mass (Gravenor 1957). Ice stagnation features such as kames and eskers along with some related ice-contact deposits are common in the northern part of the report area. The eskers were deposited by meltwaters flowing through tunnels or crevasses in the ice and form long sinuous ridges on the present-day land surface. Kames are hummocky features deposited by meltwaters in fissures, or depressions in the ice surface or at its margin. Several other ice-contact features were also formed during stagnation of the ice mass. All these ice stagnation features consist of stratified sand and gravel and are generally well suited for the production of a variety of aggregate products. Other ice stagnation features, referred to as 'ice block ridges' by Deane (1950) and Gravenor (1957), are common in the west-central part of Cavan Township and consist predominantly of clay till which has little value as aggregate.

As the ice front retreated to the north, glacial meltwaters were ponded in several depressions of the land surface between the ice and the Oak Ridges Moraine. A thin, patchy veneer of lacustrine sand was deposited in the shallower parts of these lakes while in the deeper waters silt and clay were deposited. Further retreat of the ice front from the area

resulted in the opening of a major outlet for water flowing from Lake Algonquin to Lake Iroquois (ancient Lake Ontario). This outlet followed a course encompassing the present Trent River system. An ancient Otonabee River provided one pathway for the considerable volume of water flowing through this spillway system. As water flowed through the Otonabee spillway, south of the City of Peterborough, the width of the spillway increased as water flowed into a basin situated in the central part of the report area (Gravenor 1957). In this basin a broad lacustrine sand plain was deposited. The width of the spillway decreased as the water flowed out of this basin into ancient Rice Lake and less extensive lacustrine and outwash sediments were deposited in southeastern South Monaghan Township.

The outwash deposits situated in the report area were either deposited in close association with the retreating ice margin or with the Otonabee spillway (Gravenor 1957). The outwash generally consists of uniformly-bedded, well stratified sand and gravel. Those outwash deposits associated with the spillway tend to be coarse and thicker than those related to the retreating ice margin and better suited for possible extractive development.

Postglacial erosional and depositional processes have been of relatively minor importance in modifying the physiography of the report area. The till plain has in certain areas been dissected by erosion forming large valleys, and poor drainage in several depressions has led to the development of large marshes.

EXTRACTIVE ACTIVITY

Ninety-three sand and gravel pits have been identified in Cavan, North Monaghan and South Monaghan Townships. The majority of these have been developed within ice-contact deposits, notably the Oak Ridges Moraine. Many pits have also been opened in kame, esker, outwash and lacustrine deposits. At the time of writing, seven pits were licenced to operate having a total area of 352.0 acres (142.4 ha).

The townships were designated in 1975 under the Pits and Quarries Control Act. Since designation, records of the total annual production from all licenced sources have been maintained by the Lindsay District Office of the Ontario Ministry of Natural Resources. The average annual production in the six year period between 1977 and 1982 has been approximately 161,000 tons (146 000 tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the deposits which contain granular materials. These deposits occupy a total area of approximately 38,500 acres (15 600 ha), containing a tonnage of 1650 million tons (1500 million tonnes). Many of these potential resource areas have limited value for reasons of deposit size, thickness, previous extraction or quality of the material. Consequently, only the most significant sources are suggested for protection at the primary level of significance.

The sand and gravel deposits selected for possible resource protection are shown on Map 2. Three areas in the northwestern part of Cavan Township consisting of ice-contact, esker and kame deposits have been selected as Sand and Gravel Resource Areas of Primary Significance. Two outwash deposits in northeastern South Monaghan Township have also been selected at the primary level. These Primary Resource Areas have approximately 1180 acres (480 ha) currently available for extraction and have estimated sand and gravel resources of 58 million tons (53 million tonnes). The parts of the selected areas which are available for extraction represent 3 percent of the total area occupied by sand and gravel deposits in the report area and 4 percent of the original resource tonnage.

Several ice-contact deposits have also been selected at the secondary level of significance. These deposits tend to be limited in respect to the suitability of the material or the amount of available resources. Development and exploration costs may also be high in some of these deposits. The secondary resources, however, add significantly to the resource base of the report area and care should be taken to ensure the continuing availability of as much of the remaining resources as possible.

Several pits in the townships have been tested by the Ontario Ministry of Transportations and Communications (M.T.C.). Deike (1982) reports that in these pits the gravel quality is generally excellent and acceptable for such high-specification uses as hot-laid asphalt and structural concrete. The main factor restricting the suitability of the aggregate, however, is the excessive sandy nature of the material in many of the pits. The gravel is usually concentrated in pockets within the sandy aggregate necessitating selection and sand control procedures to produce a suitable crushed product. Silt and clay seams as well as till overburden may be present in some of the pits which also limits the suitability of the aggregate.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 consists of two kame and five esker deposits located in the northwestern part of Cavan Township. The eskers occur as a series of segmented, sinuous ridges. The kames exhibit a complex, hummocky topography. Three pits have been developed in Resource Area 1.

Extractive development in licenced property nos. 1 and 2 have been largely concentrated in the esker deposits. In pit no. 1, between 20 and 50 feet (6 and 15 m) of medium to coarse gravel is exposed in the esker ridge. This material was sampled and contained 76 percent gravel and 24 percent sand (Figure 2a). Deike (1982) reports that the aggregate in this pit is suitable for uses including Hot-Laid (H.L.) No. 4 and 8 stone, 16 mm Crushed A and B, and granular base course. Blending would be required to produce hot-laid asphaltic sand. Within some areas of the licenced property sand pockets are abundant, limiting high-specification use of the aggregate. Similar quality gravel is exposed in pit no. 2. Faces in this pit expose 30 to 75 feet (9 to 23 m) of medium to coarse gravel with variable sand pockets and minor silt seams. In both the pits, oversize clasts are present

which should be removed or crushed in a primary crusher and sand control may be required in sections of the pits to produce crushed products.

Gravel of similar quality to that exposed in pits nos. 1 and 2 may be available from the undeveloped esker segments in the Resource Area. Although subsurface information is lacking for these segments, considerable amounts of gravel were observed on the surface of these deposits.

One pit has been developed in the kame deposits in the Resource Area. Faces in pit no. 12 expose 20 feet (6 m) of predominantly gravelly sand. In several road-cuts kame material is also exposed. These cuts revealed aggregate containing marginal quantities of gravel. Although the kame deposits tend to contain a relatively larger sand component than the esker deposits, with selection and sand control a suitable crushed product may be produced.

Resource Area 1 occupies 445 acres (180 ha), exclusive of licenced properties. Cultural constraints and previous extraction reduce the area currently available to 380 acres (154 ha). Assuming an average deposit thickness of 25 feet (8 m), available resources are estimated to be 24 million tons (22 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is an ice-contact deposit located near the western border of Cavan Township. The deposit lies along the side of a valley and generally consists of sandy gravel although accumulations of sand occur. Six pits have been developed in the Resource Area, of which one (pit no. 3) is currently licenced to operate.

Faces in pit nos. 3, 19 and 20 range from 3 to 30 feet (1 to 9 m) high and expose sandy gravel generally suitable for the production of H.L. 4 and 8 stone, 16 mm Crushed A and B, and granular base course (Deike 1982). Sand control may, however, be required for crushing in these sources. A sample taken of the material in pit no. 19 contained 61 percent gravel and 39 percent sand (Figure 2a). Several test holes placed in the western part of the deposit by M.T.C. revealed gravel contents ranging from 45 to 75 percent (Deike 1982).

Fine aggregate is exposed in pit nos. 21 and 22. Faces in these pits range from 8 to 20 feet (2 to 6 m) high and reveal material ranging from sand to gravelly sand. Possible uses of this material include Granular Base Course (G.B.C.) B and C along with select subgrade uses. Test hole CV-TH-3 placed in the Resource Area uncovered 20 feet (6 m) of medium sand over clay.

Resource Area 2 occupies approximately 700 acres (285 ha), exclusive of the licenced property. Cultural setbacks and previous extraction reduce the available area to 530 acres (214 ha). Assuming an average deposit thickness of 20 feet (6 m), sand and gravel resources are estimated to be 26 million tons (24 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 is a complex glacial feature consisting of both esker and kame sediments located in the extreme northwestern corner of Cavan Township. The deposit also extends outside the study area southwestward into Manvers Township and northward into Emily Township where this source has also been selected for possible resource protection (Ontario Geological Survey 1980a, b). Although exposures of the material forming the deposit in Cavan Township are limited, several pits have been developed in this esker-kame complex in Manvers and Emily Townships. The aggregate exposed in these pits usually consists of poorly to moderately sorted sand and stratified fine to coarse gravel. This material is generally suited for the production of a wide range of aggregate products. Considerable quantities of oversize material are often present in these pits which must be removed or crushed in a primary crusher. Based on this data, similar quality sand and gravel may be expected in Resource Area 3.

Resource Area 3 occupies 60 acres (24 ha) currently available for extraction. Assuming an average deposit thickness of 16 feet (5 m), aggregate resources are estimated to be 2 million tons (2 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 includes two outwash deposits located in the northeastern corner of South Monaghan Township. Two pits have been developed in this Area. Faces in licenced property no. 7 revealed 8 feet (2 m) of clean, well stratified, sandy fine gravel. Similar material was observed in the 10- to 20-foot (3 to 6 m) faces in pit no. 89, although a slightly higher percentage of coarse gravel was present. Possible uses of the aggregate exposed in these pits include G.B.C. B and C, and select subgrade material. Sand control measures would probably be neccessary to produce a suitable crushed product for G.B.C. A and higher specification uses. Further testing of the sand fraction of the aggregate would be required to determine acceptability for hot-laid asphaltic sand.

Resource Area 4 occupies 305 acres (123 ha), exclusive of the licenced property. Cultural setbacks and previous extraction reduce the area currently available to 215 acres (87 ha). Assuming an average deposit thickness of 12 feet (4 m), sand and gravel resources are estimated to be 6 million tons (5 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Several ice-contact deposits have been designated as Sand and Gravel Resource Areas of Secondary Significance. Although these deposits are not considered the "best" resources, they add significantly to the resource base of the townships and should be considered an important part of the total aggregate supply.

A vast area of the Oak Ridges Moraine in southern Cavan Township has been selected at the secon-

dary level of significance. Thirty-one pits have been developed in this deposit. Material exposed in these pits generally consists of sandy aggregate, although pockets of quality gravel occur locally. Appreciable quantities of gravel were observed in pit nos. 5, 61 62, 63, 73, 75 and 76. The gravel present in licenced pit no. 5 is suitable for a wide variety of aggregate products including hot-laid asphaltic stone, 16 mm Crushed A and B, and granular base course (Deike 1982). Similar products have been produced from pit nos. 61, 62 and 63, however, selection and sand control measures are required as the gravel occurs as isolated pockets within the sandy sediment. The remaining pits in the Oak Ridges Moraine are dominantly sand sources suitable for the production of G.B.C. B and C as well as select subgrade material. The sand fraction of the aggregate from pits in this deposit would require blending for use as hot-laid asphaltic sand.

A considerable area in the Oak Ridges Moraine remains undeveloped and significant amounts of aggregate are currently available for possible extraction. Pockets of high-quality gravel occur in localized areas within the moraine and further exploration may uncover greater quantities of this resource. The predominance of sand on the surface of the moraine may increase the costs of exploration and development.

Two ice-contact deposits located south of the community of Cavan in the central part of Cavan Township have also been selected. Three pits (pit nos. 35, 36 and 37) have been developed in the westernmost deposit. Faces in the pits range from 5 to 20 feet (1.5 to 6 m) and expose mainly sand with some minor gravel pockets. Test hole CV-TH-7 was placed in the floor of pit no. 35 and revealed 9 feet (3 m) of sand below which a gravel layer was encountered. Deike (1982) reports that the material in these pits is generally suitable for G.B.C. B and C, and select subgrade uses. Concentrations of gravel are relatively more abundant in the easternmost deposit. Two pits have been developed in this deposit. In pit no. 39 faces revealed sand similar to that exposed in the previous deposit, however, a 12-foot (4 m) thick quality gravel pocket was observed in the western face of the pit. With selection and sand control, products such as 16 mm Crushed B and G.B.C. A may be produced where concentrations of gravel are encountered in this deposit.

An ice-contact deposit surrounds part of Primary Resource Area 1. One pit has been opened in the deposit exposing 5 to 10 feet (1.5 to 3 m) of sand. Sand was also uncovered to a depth of 37 feet (11 m) in test hole CV-TH-1. Although considerable quantities of sandy aggregate may be available from the deposit, local accumulations of gravel were observed on the surface. Further investigation may reveal additional gravel resources.

An ice-contact deposit is situated in North Monaghan Township along the city limits of Peterborough. Little subsurface information is available for this deposit, however, information pertaining to deposits of similar origin in the area indicate a range of aggregate products may be produced.

The final areas selected at the secondary level are three buried ice-contact deposits located in central Cavan Township. With the exception of one pit, the pits opened in these deposits contain high-quality gravel suitable for the production of a wide variety of aggregate products. The till which overlies the aggregate in these pits is relatively thin, generally less than 10 feet (3 m) thick. Outside these extracted areas the thickness of the till is largely unknown, especially where water well and section data are lacking. The extent and distribution of these buried deposits have been based largely on topographic considerations and limited available subsurface information. Therefore, further testing may be required to delineate specific sites suitable for extractive development.

Three pits have been developed in the buried gravel deposit situated near Dranoel Station. Faces in pit nos. 8b and 8c exposed up to 55 feet (17 m) of sandy gravel suitable for use as H.L. 4 and 8 stone, 16 mm Crushed A and B, and granular base course. Clay till overburden is up to 4 feet (1.2 m) thick in the southern faces of this source and silt seams were observed in places within the sand and gravel. In licenced pit no. 4, 20 to 35 feet (6 to 11 m) of medium to coarse gravel was observed. The aggregate exposed in this pit appears to be of high quality, although occasional sand pockets and minor silt and clay lenses were observed. Just east of pit no. 4 at described section CV-DS-1, similar quality gravel was exposed beneath 20 feet (6 m) of clay till. Water wells east of the described section indicate a variable thickness of till overburden.

Two of the buried deposits are located near Ida. Faces in pit nos. 25 and 26 expose up to 50 feet (15 m) of sandy gravel suitable for use as hot-laid asphaltic stone, 16 mm Crushed A and B and granular base course. The aggregate is overlain by up to 10 feet (3 m) of till in these pits. Several test holes placed in the vicinity of these sources by M.T.C. revealed aggregate containing between 30 and 80 percent gravel. Fine aggregate was observed in pit no. 27 where faces revealed 10 feet (3 m) of sand with occasional gravel pockets. Additional resources of gravel may be available from the presently undeveloped parts of these deposits.

The remaining deposits in the report area have been designated as tertiary resources. Several of these deposits are suitable for extraction of aggregate for local use in the area. In others, quality and subsurface data are lacking. Future exploration may uncover additional quantities of suitable aggregate.

BEDROCK GEOLOGY

The townships are underlain by bedrock of the Middle Ordovician Verulam Formation and the Middle to Upper Ordovician Lindsay Formation. The Verulam Formation underlies the eastern part of the report area and consists of medium- to coarse-grained limestone with interbedded shale (Carson 1980a, b). This formation has been quarried for lime elsewhere in southern Ontario, but is generally not well suited for the production of load-bearing aggregate.

The Lindsay Formation overlies the Verulam Formation in the western part of the report area. The

Lindsay Formation consists of fine-grained, nodular, shaly limestone (Dolar-Mantuani 1975). Similar to the Verulam, the Lindsay Formation is suitable for lime production, but not for the production of load-bearing aggregate. The formation has been extracted along the shore of Lake Ontario, east of Toronto, for use as a raw material in cement manufacture.

A considerable thickness of drift overlies the bedrock. In most of the report area and in several wells the overburden exceeds 200 feet (61 m) deep. The drift thickness decreases in the eastern part of the townships near the Otonabee River, but since the formations are generally covered by overburden in excess of 25 feet (8 m), no areas have been selected for possible resource protection.

SUMMARY

The sand and gravel deposits of Cavan, North Monaghan and South Monaghan Townships are the product of glacial activity which occurred during the Late Wisconsinan. Three areas in Cavan Township containing ice-contaci, esker and kame materials have been selected as Sand and Gravel Resource Areas of Primary Significance. Two outwash deposits in South Monaghan Township have also been selected at the primary level. In addition, several ice-contact deposits have been designated as resources of secondary significance. Significant amounts of aggregate suitable for a variety of road-building and construction uses are available from these primary and secondary resources.

Drift thickness in the report area is generally too great to permit economic extraction of the underlying Verulam and Lindsay Formations.

Enquiries regarding the Aggregate Resources Inventory of Cavan, North Monaghan and South Monaghan Townships should be directed to the Aggregate Assessment Office, Ontario Geological Survey, Ministry of Northern Affairs and Mines at Room M1B-45, Macdonald Block, Queen's Park, Toronto, M7A 1W3 (Tel. (416) 965-1663), or to the Ontario Ministry of Natural Resources, either at the Lindsay District Office, 322 Kent Street West, Lindsay, Ontario K9V 4T7 (Tel. (705) 324-6121) or at the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS*.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
Cavan Township			
1	G-E	156 (63)	10 (9)
	G-IC	1570 (640)	90 (82)
	S-IC	12,100 (4900)	1030 (930)
	G-K	410 (166)	26 (24)
2	G-E	8 (3)	<1 (<1)
	G-E-K	60 (24)	2 (2)
	G-IC	590 (239)	22 (20)
	S-IC	46 (19)	2 (2)
	S-IC-LP	106 (43)	5 (4)
	S-K	4 (2)	<1 (<1)
	S-LP	990 (400)	27 (24)
3	S-IC	1030 415	21 (19)
	S-LP	9300 (3750)	186 (169)
	S-OW	1050 (425)	16 (14)
4	S-IC	215 (87)	2 (2)
	S-LP	1270 (510)	13 (12)
	S-OW	30 (12)	<1 (<1)
		29,000 (11 700)	1450 (1320)
North Monaghan Township			
1	S-IC	225 (91)	12 (11)
2	G-IC	10 (4)	<1 (<1)
	S-IC	53 (21)	2 (2)
	S-K	20 (8)	1 (1)
3	S-IC	36 (15)	1 (1)
	S-LP	4100 (1600)	82 (74)
	S-OW	300 (121)	4 (4)
4	S-IC	160 (65)	1 (1)
	S-LP	45 (18)	<1 (<1)
	G-OW	225 (91)	2 (2)
		5200 (2100)	105 (95)
South Monaghan Township			
2	S-LP	700 (285)	21 (19)
	G-OW	320 (130)	10 (9)
3	S-IC	90 (36)	2 (2)
	S-LP	2500 (1010)	50 (45)
	G-OW	550 (223)	10 (9)
	S-OW	190 (77)	3 (3)
4	S-LP	44 (18)	<1 (<1)
	S-OW	68 (28)	1 (1)
		4450 (1880)	97 (88)
Total Report Area:		38,500 (15 600)	1650 (1500)

* Deposits within the City of Peterborough and the Village of Millbrook have been omitted on all tables.

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2. SAND AND GRAVEL PITS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
LICENCED PITS							
Cavan Township							
1	L04-102 L04-142	Fred Nelson & Sons Ltd.	10	14	38.0 (15.4)	20-50 (6-15)	50-80
2	L04-125	Township of Cavan	7,8	13	100.0 (40.5)	30-75 (9-23)	45-65
3	S02-146	A. Bigelow	1	9,10	23.7 (9.6)	30 (9)	30-40
4	S02-152	Township of Cavan	6	6	30.0 (12.1)	20-35 (6-11)	50-65
5	R04-032	Harnden & King Construction Ltd.	6	4	20.0 (8.1)	60 (18)	10-65
					211.7 (85.7)		
North Monaghan Township							
6	R04-131	C. Johnston	2	9	107.1 (43.3)	10-30 (3-9)	- mainly sand
South Monaghan Township							
7	-	Whittington	20,21	4,5	33.2 (13.4)	8 (2)	40-60
					352.0 (142.4)		
UNLICENCED PITS*							
Cavan Township							
8a	S02-035	Highland Creek Sand and Gravel Co. Ltd.	2	7		15-20 (5-6)	- mainly sand
8b	S02-035	Highland Creek Sand and Gravel Co. Ltd.	2	7		15-55 (5-17)	20-50
8c	S02-035	Highland Creek Sand and Gravel Co. Ltd.	2	7		55 (17)	20-50
9	-	unknown	1	14		5 (1.5)	- overgrown, gravel at surface
10	-	unknown	4	12		10-15 (3-5)	40-50
11	-	unknown	5	14		5-10 (1.5-3)	- sand
12	L04-157	Wilson	9	14		20 (6)	10-25
13	-	unknown	12	14		15 (5)	- variable
14	-	unknown	14	13		5-20 (1.5-6)	- variable

* Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 2. SAND AND GRAVEL PITS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
15	-	unknown	16	14		5-10 (1.5-3)	- till
16	P09-031	unknown	21	14		20 (6)	- mainly sand, overgrown
17	-	unknown	21	14		10-20 (3-6)	<10
18	P09-068	unknown	22	14		5-15 (1.5-5)	10 gravel pockets
19	-	E. Morton	4	10		3-12 (1-4)	50-65
20	-	unknown	4	10		20 (6)	30-40
21	-	unknown	5	10		15-20 (5-6)	<5
22	-	unknown	6	10		8 (2)	20-25
23	-	unknown	7	10		7-10 (2-3)	- overgrown
24	-	unknown	8	9		5 (1.5)	- sand
25	R04-031	Harvey	9	9		50 (15)	20-50 variable
26	R04-098	Bluestien (Sharpe)	11,12	10		30 (9)	10-50 variable
27	R04-051	unknown	12	10		10 (3)	- mainly sand
28	R04-030	unknown	13	10		10 (3)	- variable
29	R04-057	unknown	19	10		3-5 (1-1.5)	- mainly sand
30	R04-065	unknown	19	11		5-10 (1.5-3)	- variable
31	R04-074	unknown	21	9		10-25 (3-8)	30-40
32	-	unknown	20	8		10 (3)	- overgrown and partially water filled
33	R04-166	Bothwell	19	8		15 (5)	- mainly sand
34	-	unknown	17	8		10 (3)	- mainly sand
35	R04-050	Robinson	9	8		5-15 (1.5-5)	- mainly sand
36	R04-078	unknown	10	7		20 (6)	- mainly sand
37	R04-002	unknown	10	7		20 (6)	- mainly sand

TABLE 2. SAND AND GRAVEL PITS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
38	-	unknown	16	7		10 (3)	- overgrown
39	R04-100	Larmer	18	7		20 (6)	- sand with gravel pockets
40	R04-049	unknown	18	7		10-15 (3-5)	- overgrown
41	-	unknown	12	6		15-20 (5-6)	50
42	-	unknown	23	6		3-5 (1-1.5)	- sandy, overgrown
43	R04-137	unknown	18	6		4-8 (1.2-2)	- mainly sand
44	-	unknown	20	4		5-10 (1.5-3)	- sand
45	S02-016	Todd	1	4		5-8 (1.5-2)	10-20
46	S02-030	Wood	1	4		3-6 (1-2)	25
47	S02-031	unknown	2	4		10 (3)	- sand
48	-	unknown	10	5		3-5 (1-1.5)	- sand
49	-	unknown	10	5		50-60 (15-18)	- sand
50	-	unknown	8	4		20-25 (6-8)	- sand
51	-	unknown	10	4		5-10 (1.5-3)	- overgrown
52	-	unknown	10	4		5-10 (1.5-3)	- overgrown
53	-	unknown	9	4		5-8 (1.5-2)	- overgrown
54	-	unknown	8	4		17 (5)	- variable
55	-	unknown	8	4		5-15 (1.5-5)	- mainly sand
56	-	unknown	5	3		5-15 (1.5-5)	15-25
57	-	unknown	12	3		25 (8)	- variable
58	-	unknown	11	3		20 (6)	5-10
59	-	unknown	11	3		10 (3)	- variable
60	-	unknown	9	3		15-20 (5-6)	20 variable

TABLE 2. SAND AND GRAVEL PITS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
61	R04-144	Elgar	9	3		30-40 (9-12)	- sand with gravel pockets
62	R04-052	Hard	8	2		60-70 (18-21)	- sand with gravel pockets
63	R04-139	Brown	7	2		60-70 (18-21)	- sand with gravel pockets
64	-	unknown	9	2		20 (6)	- sand
65	-	unknown	9	2		10 (3)	- sand
66	-	unknown	9	2		5-15 (1.5-5)	- sand
67	-	unknown	9	2		20-35 (6-11)	- mainly sand
68	-	unknown	9	1		5-10 (1.5-3)	- sand
69	-	unknown	12	2		10 (3)	- sand
70	R04-045	unknown	14	2		5-10 (1.5-3)	10-40 variable
71	-	unknown	15	2		8 (2)	20
72	R04-046	Gillis	15	2		20-30 (6-9)	5
73	-	unknown	14	1		20 (6)	35-50
74	-	unknown	13	1		15 (5)	- mainly sand
75	-	unknown	13	1		10-20 (3-6)	20-40 variable
76	-	unknown	15	1		5-10 (1.5-3)	20-40

TABLE 2. SAND AND GRAVEL PITS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
North Monaghan Township							
77	-	unknown	4	11		10 (3)	- sand pockets in till
78	-	unknown	3	11		5-20 (1.5-6)	4 ft. (1.2m) gravel over till
79	-	unknown	1	8		5 (1.5)	- sand
80	-	unknown	1	8		4-8 (1.2-2)	- mainly sand, overgrown
81	-	unknown	1	8		8-20 (2-6)	- variable, till over gravel
82	-	unknown	3	8		3 (1)	- sand
South Monaghan Township							
83	-	unknown	3	6		5-20 (1.5-6)	- mainly sand
84	-	unknown	4	6		5-15 (1.5-5)	- sand
85	-	unknown	12	4		8 (2)	- sand
86	-	unknown	11,12	4		20 (6)	- sand
87	-	unknown	13	4		10 (3)	- sand
88	-	unknown	15	4		3 (1)	- sand
89	R04-146	unknown	18	4		10-20 (3-6)	30-50
90	-	unknown	17	3		5 (1.5)	20-35
91	-	unknown	15	2		5-8 (1.5-2)	- till
92	-	unknown	10	2		5 (1.5)	- overgrown
93	-	unknown	6	A		8-20 (2-6)	- overgrown

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 Deposit No.	2 Unlicenced Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
Cavan Township						
1	445 (180)	60 (24)	5 (2)	380 (154)	25 (8)	24 (22)
2	700 (285)	150 (61)	20 (8)	530 (214)	20 (6)	26 (24)
3	60 (24)	0 (0)	0 (0)	60 (24)	16 (5)	2 (2)
	1200 (485)	210 (85)	25 (10)	970 (395)		52 (47)
North Monaghan Township			- NONE -			
South Monaghan Township						
4	305 (123)	65 (26)	25 (10)	215 (87)	12 (4)	6 (5)
Total Report Area	1500 (610)	275 (111)	50 (20)	1180 (480)		58 (53)

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCES, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
Cavan Township				
3-25 (1-8)	Lindsay	60 (18)	115 (46)	25 (23)
25-50 (8-15)	Lindsay	60 (18)	420 (170)	91 (82)
			540 (218)	116 (105)
25-50 (8-15)	Verulam	60 (18)	165 (67)	36 (33)
			700 (285)	152 (138)
North Monaghan Township				
3-25 (1-8)	Verulam	60 (18)	28 (11)	6 (5)
25-50 (8-15)	Verulam	60 (18)	1600 (650)	345 (315)
			1630 (660)	350 (320)
South Monaghan Township				
25-50 (8-15)	Lindsay	60 (18)	70 (28)	15 (14)
25-50 (8-15)	Verulam	60 (18)	1830 (740)	395 (360)
			1900 (770)	410 (370)
Total Report Area:			4250 (1720)	910 (830)

TABLE 5. QUARRIES, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 NO.	2 MTC NO.	3 OWNER/ OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
			-NONE-			

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

1 **DEPOSIT NO.**	2 **DEPTH OF OVERBURDEN** Feet (Metres)	3 **UNLICENCED AREA** Acres (Hectares)	4 **CULTURAL SETBACKS** Acres (Hectares)	5 **EXTRACTED AREA** Acres (Hectares)	6 **AVAILABLE AREA** Acres (Hectares)	7 **ESTIMATED WORKABLE THICKNESS** Feet (Metres)	8 **AVAILABLE RESOURCES** Millions of Tons (Tonnes)

-NONE-

TABLE 7. SUMMARY OF TEST HOLE DATA, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

Test Hole Number: CV-TH-1
Location: Lot 5, Conc. 13, Cavan Township
Elevation: Approximately 950 feet (290 m) a.s.l.
Date: July 8, 1982

Depth Feet (metres)	Description
0-37 (0-11)	medium **sand** with minor amounts of coarse sand and fine gravel

Test Hole Number: CV-TH-2
Location: Lot 4, Conc. 11, Cavan Township
Elevation: Approximately 925 feet (282 m) a.s.l.
Date: July 7, 1982

Depth Feet (metres)	Description
0-13 (0-4)	**clay** with occasional pebbles (till)

Test Hole Number: CV-TH-3
Location: Lot 6, 7, Conc. 10, Cavan Township
Elevation: Approximately 780 feet (238 m) a.s.l.
Date: July 8, 1982

Depth Feet (metres)	Description
0-20 (0-6)	medium **sand**
20-21 (6)	**clay**

Test Hole Number: CV-TH-4
Location: Lot 6, Conc. 9, Cavan Township
Elevation: Approximately 750 feet (229 m) a.s.l.
Date: July 8, 1982

Depth Feet (metres)	Description
0-14 (0-4)	**clay** with occasional pebbles (till)

Test Hole Number: CV-TH-5
Location: Lot 7, Conc. 8, Cavan Township
Elevation: Approximately 750 feet (229 m) a.s.l.
Date: July 8, 1982

Depth Feet (metres)	Description
0-5 (0-1.5)	clayey **silt** with some sandy silt
5-13 (1.5-4)	**clay** with occasional angular pebbles (till)

Test Hole Number: CV-TH-6
Location: Lot 3, Conc. 8, Cavan Township
Elevation: Approximately 810 feet (247 m) a.s.l.
Date: July 12, 1982

Depth Feet (metres)	Description
0-5 (0-1.5)	wet, silty medium to coarse **sand** with minor amounts of fine gravel
5-10 (1.5-3)	wet, silty **sand**

Test Hole Number: CV-TH-7
Location: Lot 9, Conc. 8, Cavan Township
Elevation: Approximately 850 feet (259 m) a.s.l.
Date: July 9, 1982

Depth Feet (metres)	Description
0-9 (0-3)	clean medium **sand** - at 9 feet (3 m) a gravel layer was encountered which the auger could not penetrate

Test Hole Number: CV-TH-8
Location: Lot 14, Conc. 7, Cavan Township
Elevation: Approximately 825 feet (251 m) a.s.l.
Date: July 9, 1982

Depth Feet (metres)	Description
0-7 (0-2)	clayey **silt** with some angular clasts (till)

TABLE 8. SUMMARY OF DESCRIBED SECTION DATA, CAVAN, NORTH MONAGHAN AND SOUTH MONAGHAN TOWNSHIPS.

Described Section Number: CV-DS-1
Location: Lot 6, Conc. 6, Cavan Township
Elevation: Approximately 975 feet (297 m) a.s.l.

Height Feet (metres)	Description
25 (8)	20 feet (6 m) of clay **till** over 5 feet (1.5 m) of sandy **gravel** with a stone content of approximately 40 to 50 percent

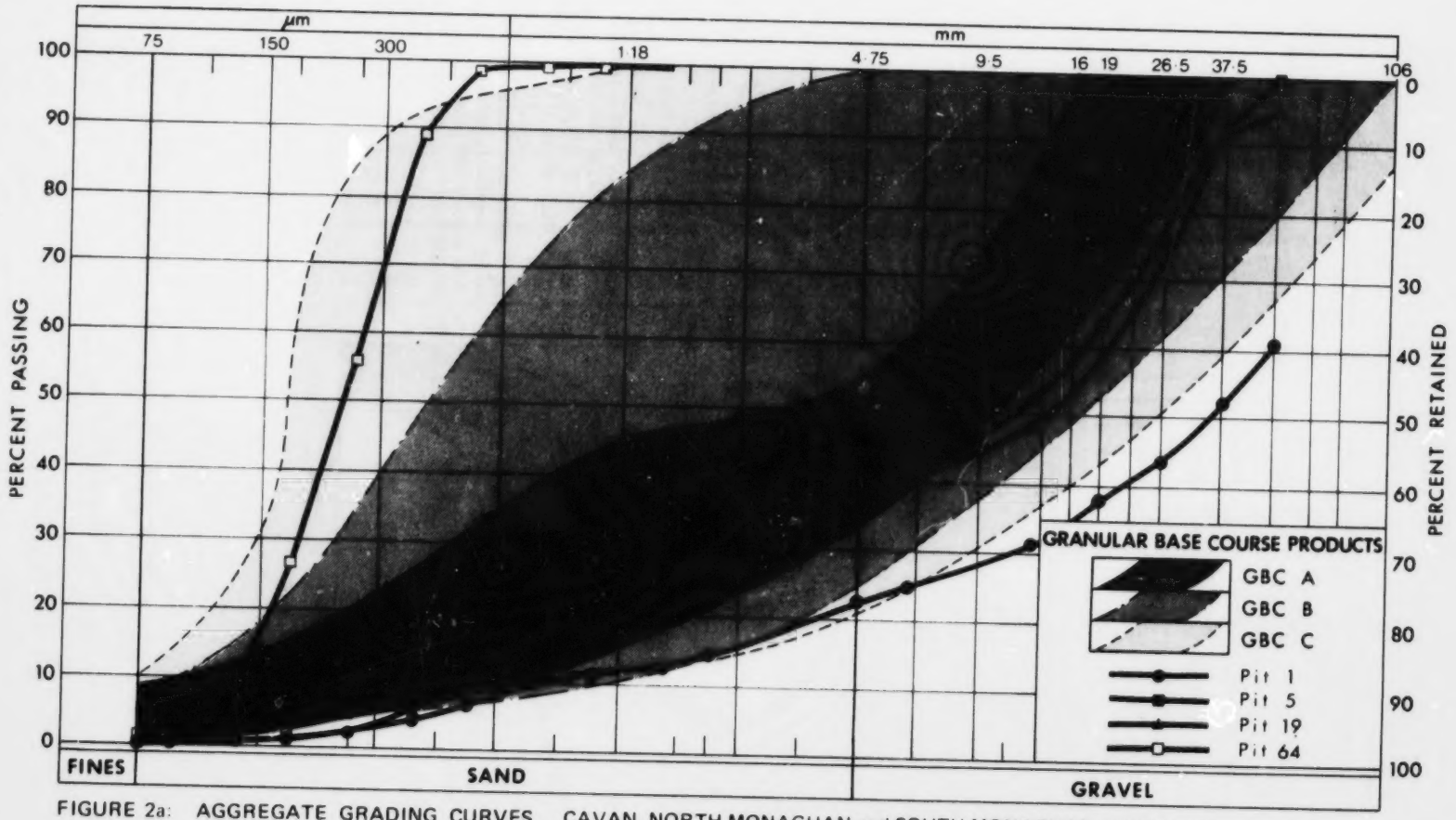


FIGURE 2a: AGGREGATE GRADING CURVES, CAVAN, NORTH MONAGHAN and SOUTH MONAGHAN TOWNSHIPS;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

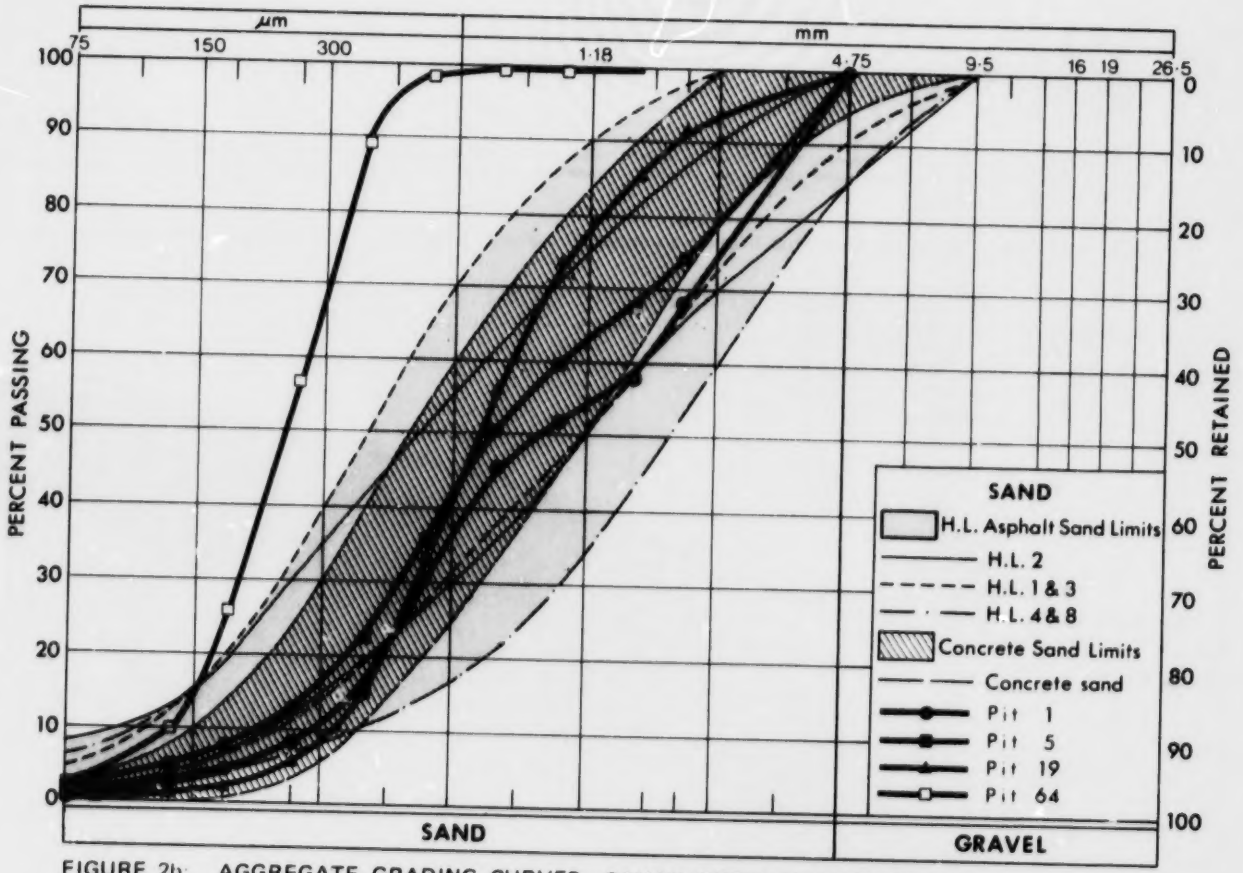


FIGURE 2b: AGGREGATE GRADING CURVES, CAVAN, NORTH MONAGHAN and SOUTH MONAGHAN TOWNSHIPS;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix A — Suggested Additional Reading

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Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Alkali-aggregate reaction: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Cambrian: The first period of the Palezoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed

aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: an early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear de-

posits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

Bass Islands Formation (Upper Silurian)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18 m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunnville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate because of high soundness losses.

Bobcaygeon Formation (Middle Ordovician)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

Bois Blanc Formation (Lower-Middle Devonian)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High cherty content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

Dundee Formation (Middle Devonian)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys as raw material for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

Gull River Formation (Middle Ordovician)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

Lockport and Amabel Formations (Middle Silurian)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine-to medium-grained dolostone.

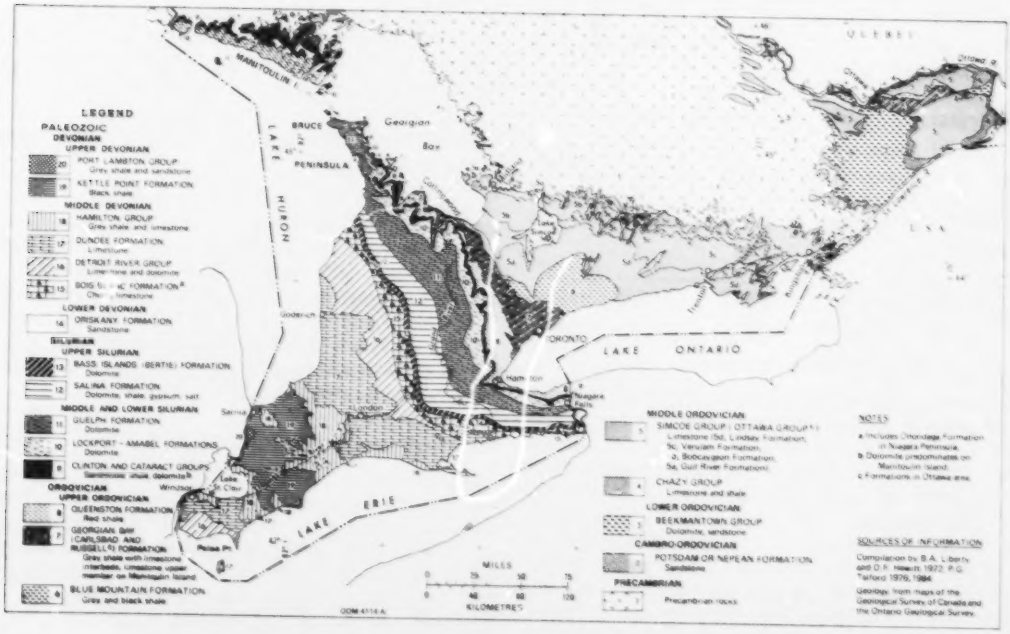


Figure 3. Bedrock Geology of Southern Ontario.

Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

Onondaga Formation (Middle Devonian)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey-brown, fine-grained, very cherty limestone having estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey-brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High cherty content makes much of the material unsuitable for concrete aggregate.

Ottawa Formation (Middle Ordovician)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of limestone for cement production and agricultural uses.

Oxford Formation (Lower Ordovician)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

Detroit River Group (Middle Devonian)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to microcrystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces much of Ontario's lime and cement. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

Grenville Marble (Precambrian)

Composition: Recrystallized fine- to coarse-grained white limestone and dolostone, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

Guelph Formation (Middle Silurian)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. Thickness: 100 to 170 feet (30 to 52 m). Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

Lindsay Formation (Upper Ordovician)

Composition: fine-crystalline, rubbly, nodular-weathering limestone. Collingwood Member: organic-rich interbedded calcareous shales and limestones. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

Verulam Formation (Middle Ordovician)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for use in cement manufacture. The formation is unsuitable for crushed stone because of clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

Georgian Bay Formation (Upper Ordovician) (Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue-grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in the vicinity of Metro Toronto produce brick and structural tile. Lightweight aggregate has been produced at Streetsville by heat expansion of the shale.

Hamilton Group (Middle Devonian)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona Formation is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). The Arkona Formation has a thickness of 14 to 121 feet (4 to 37 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile.

Queenston Formation (Upper Ordovician)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

Nepean (Potsdam) Formation (Cambro-Ordovician)

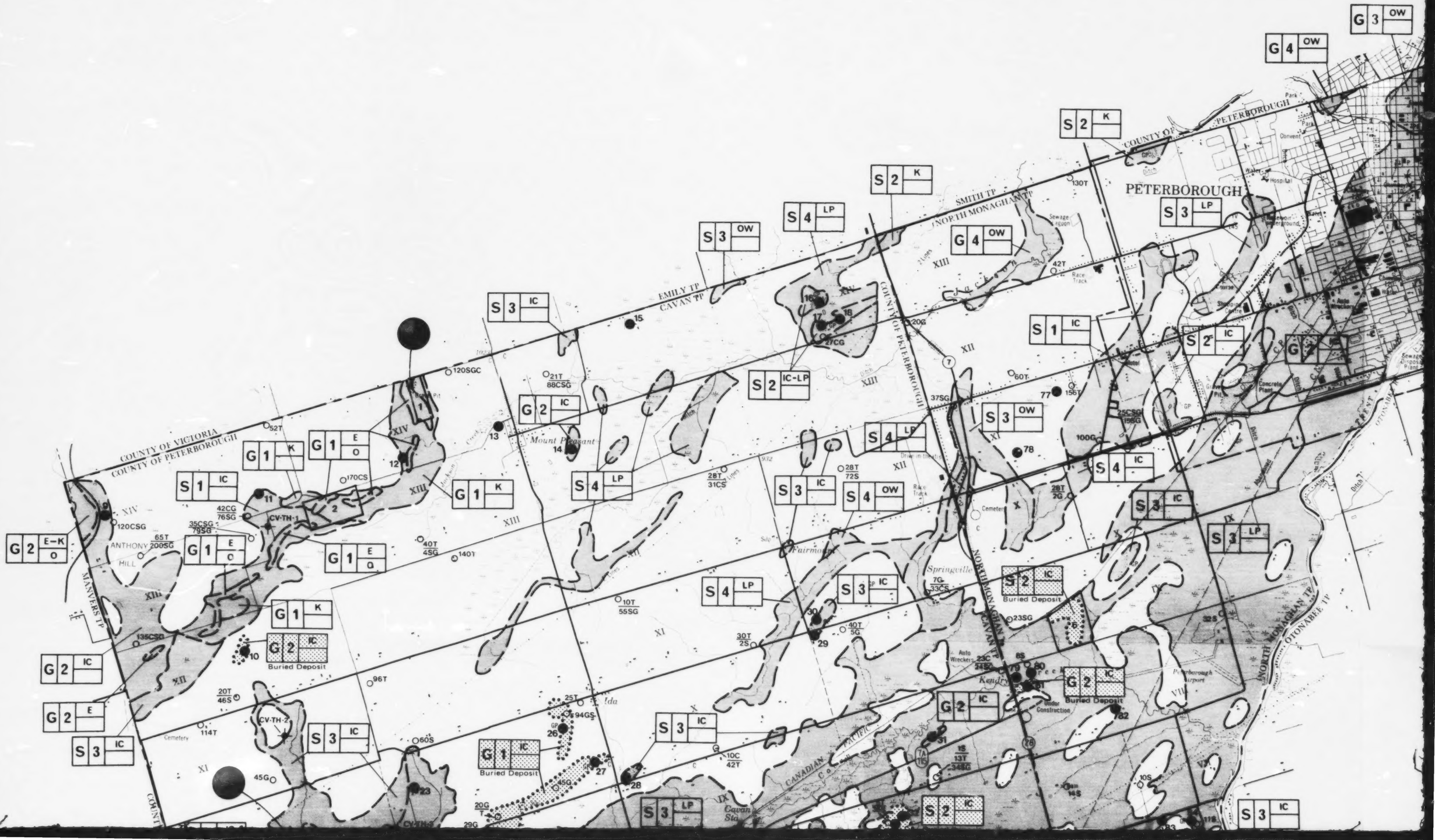
Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

Salina Formation (Upper Silurian)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

Blue Mountain Formation (Upper Ordovician)

(Formerly known as the Whitby Formation) Composition: Blue-grey, predominantly non-calcareous shale. Uses: Quarried at Bowmanville for use in cement production.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Race Track
Race Track
Hospital
Convent
Cemetery
Cemetery
Auto Wreckers
Sewage Lagoon
Sewage Lagoon
Sewage Disposal Plant
Concrete Plant
Reservoir
Reservoir
Park
Park
Golf Course
Golf Course
Drive-in Theatre
Dump
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Dump

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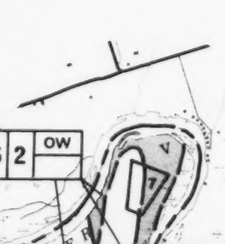

Ministry of Northern Affairs and Mines

Ontario

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

CAVAN, NORTH MONAGHAN and SOUTH MONAGHAN TOWNSHIPS

COUNTY OF PETERBOROUGH

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 31 D/1, 31D/2
31 D/7, 31D/8

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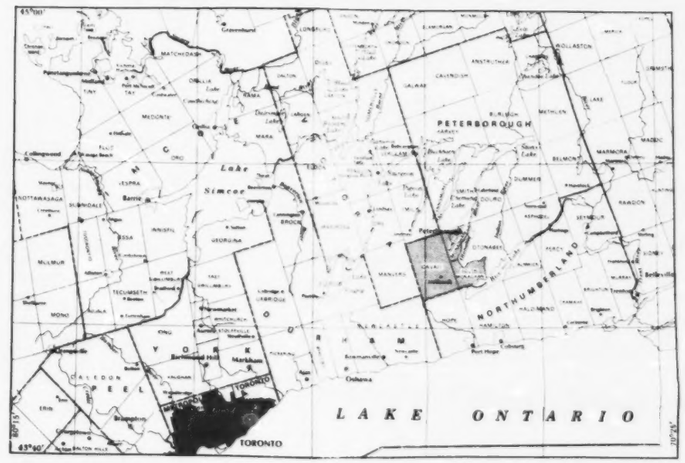


Location Map

Scale 1:1,800,00

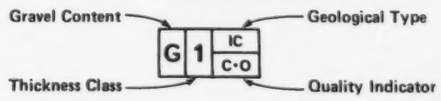
SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class

COUNTY OF PETERBO

COUNTY OF VICTORIA

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NORTH MONAGHAN TP

OTONABEE TP

SOUTH MONAGHAN TP

CAVAN TP

COUNTY OF PETERBOROUGH

CANADIAN NATIONAL

Cavan Sta

Millbrook

Millbrook South

Fraserville

Bailieboro

Springville

Kendry

Pranoel Sta

Ida

Fairmount

Wallace Point

Peterborough Airport

Cavan Creek

Baxter Creek

Abandoned

Buried Deposit

Sports Track

Auto Wreckers

Construction

Cemetery

Dam

Quarry

Pit

Tailings

Lines

Ditch

Rock Tunnel

Rock Trench

Pasture

Bush

Orchard

Marsh

Swamp

Rapids

Falls

Sand

Gravel

Clay

Loam

Stone

Boulders

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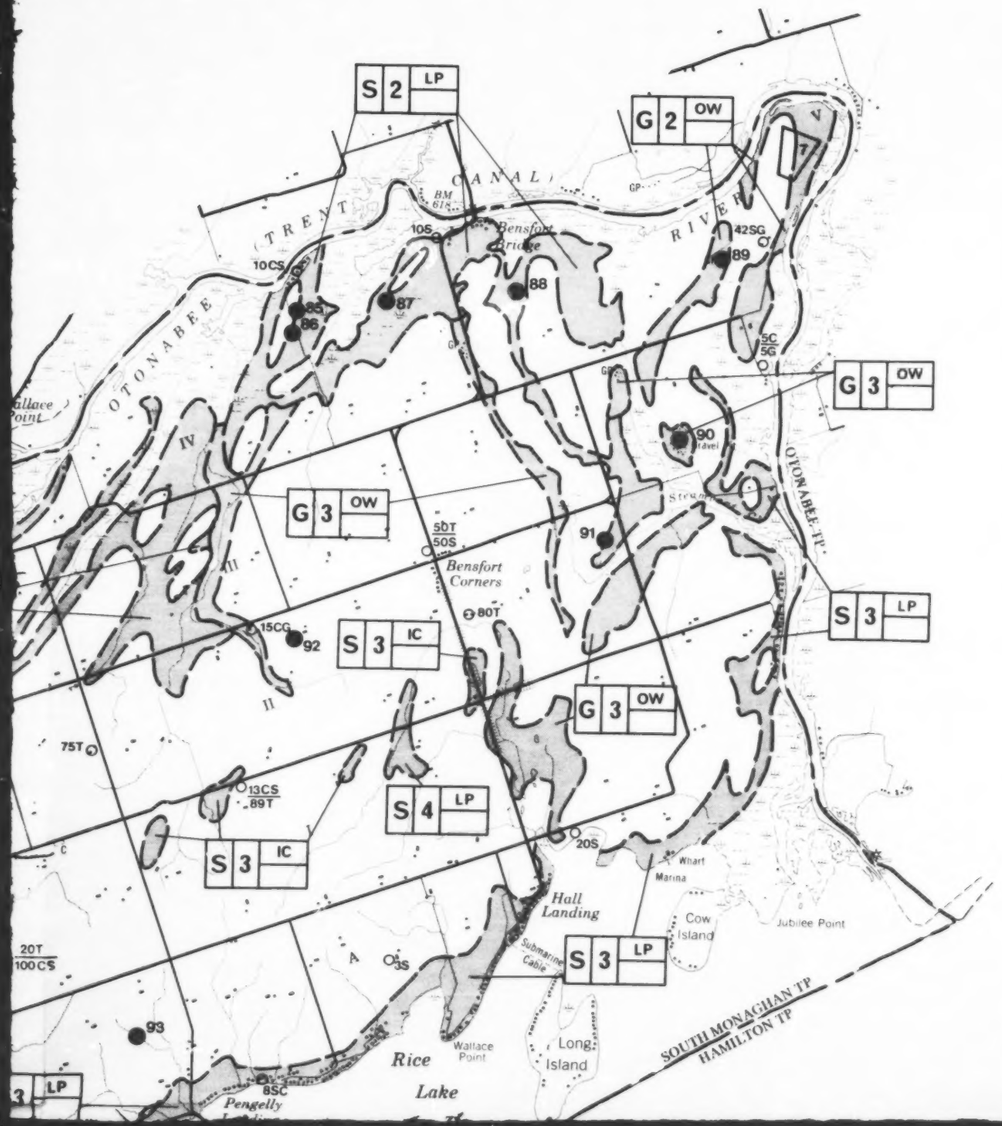


Location Map

Scale 1:1,800,00

SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

CV-TH-2 — Selected test hole location; Identification number: see Table 7.

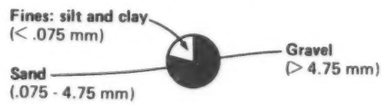
6 / 23 G — Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

G 1 IC / C·O — Deposit Symbol: see below.

Texture symbol; see below: see Figures 2a and 2b.

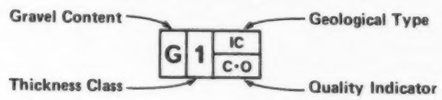
CV-DS-1 — Described section; Identification number: see Table

TEXTURE SYMBOL



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
ICT	Ice-Contact Terrace	**OW**	Outwash
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

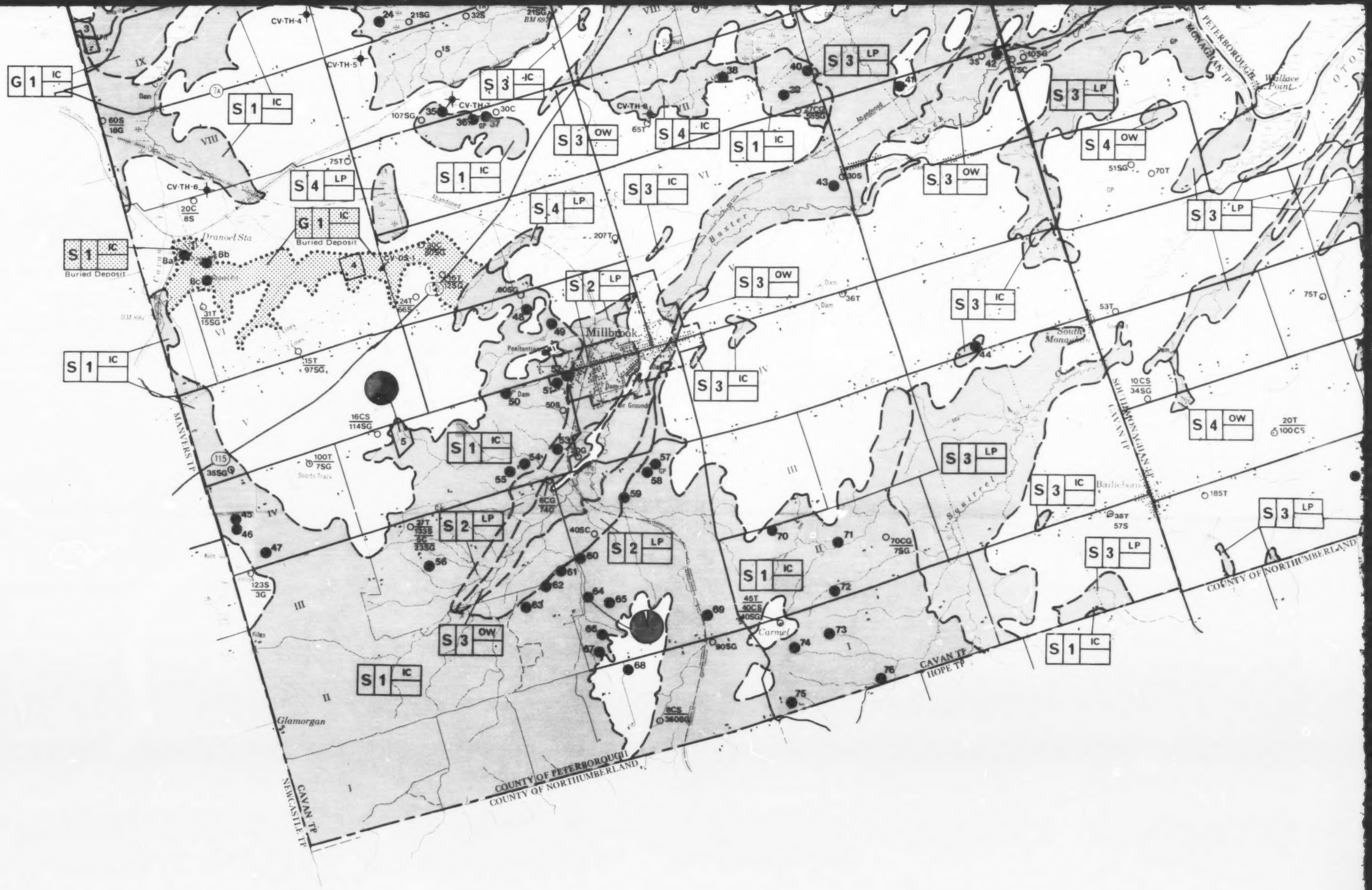
	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from Districts and Regional Offices, Ontario Ministry of

Geology by: C. P. Gravenor, 1954a, b, 1957.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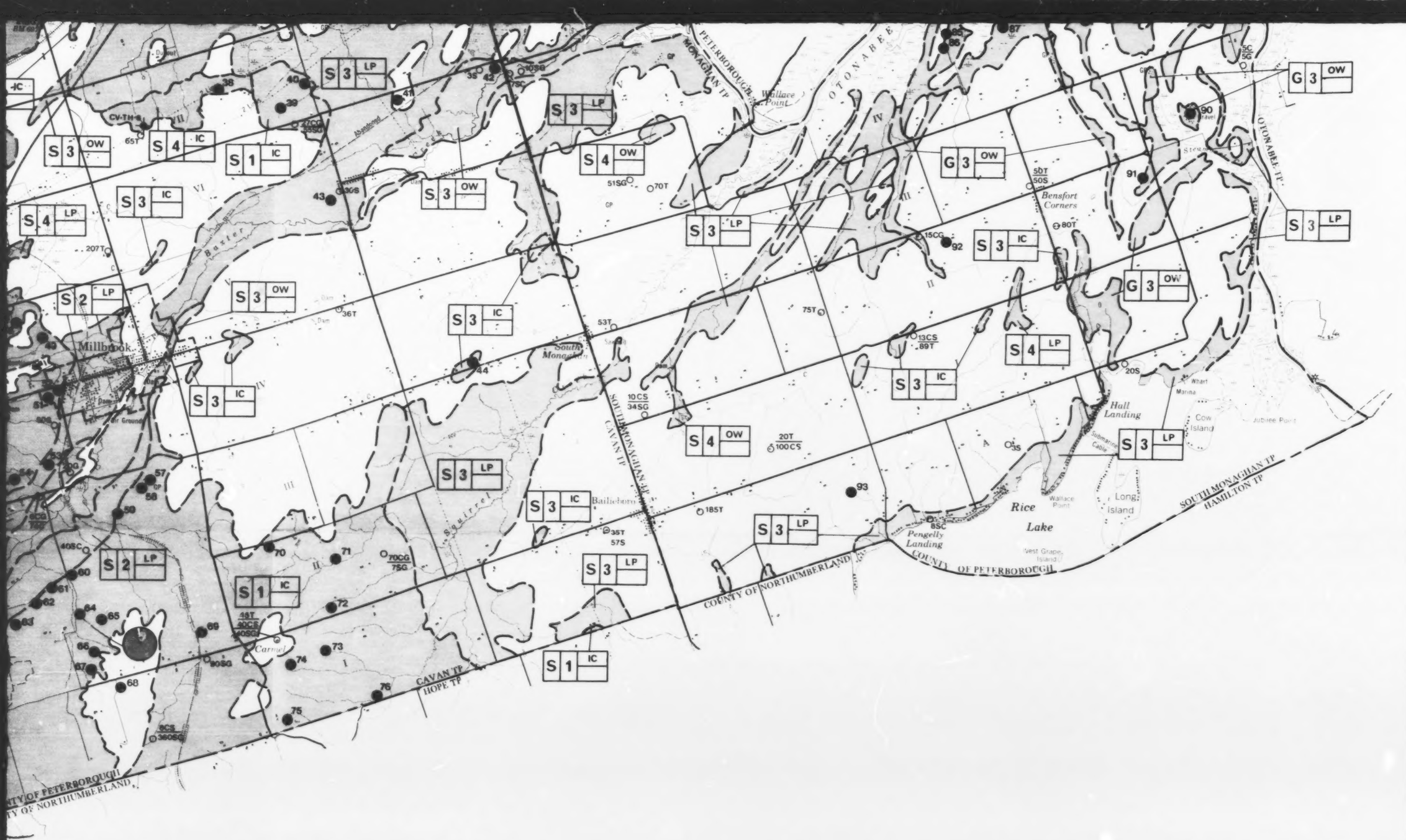

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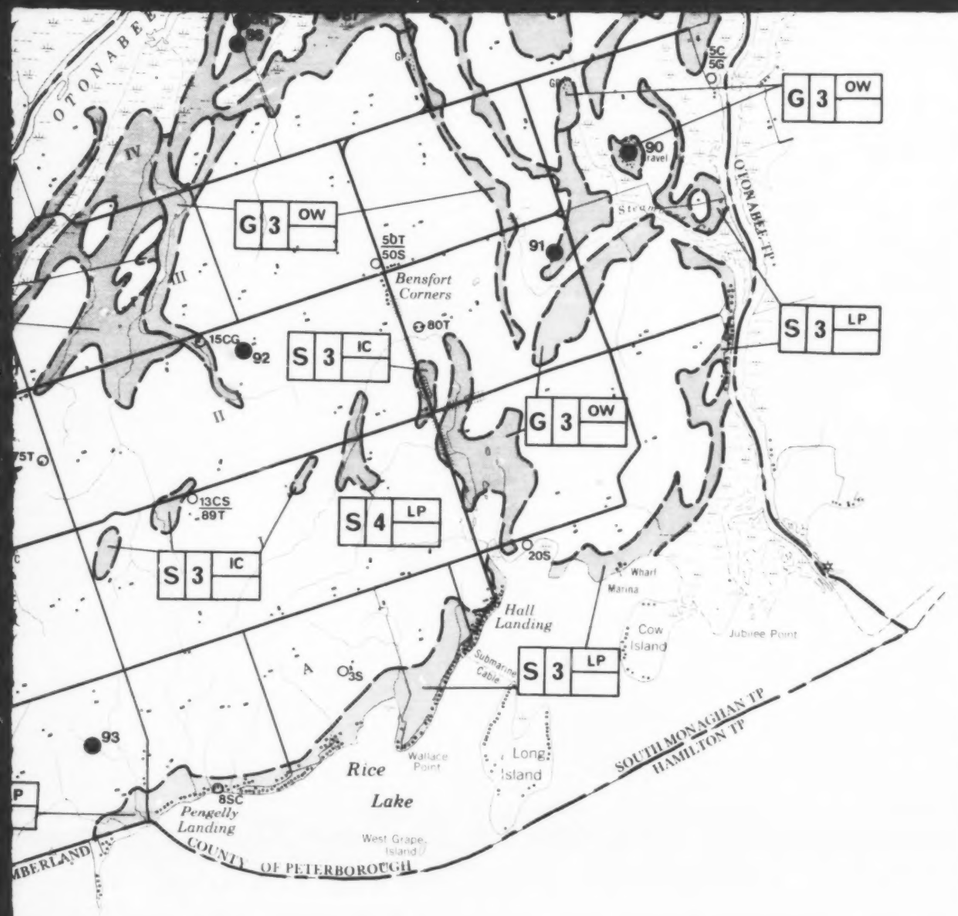
Drilling data from the Pet
Natural Resources.



CAVAN

NORTH MONAGHAN

SOUTH MONAGHAN

● 3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

✦ CV-TH-2 — Selected test hole location; Identification number: see Table 7.

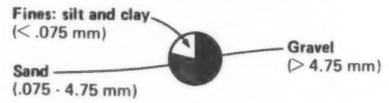
○ 6/23G — Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

G 1 IC / C·O — Deposit Symbol: see below.

Texture symbol; see below: see Figures 2a and 2b.

▲ CV-DS-1 — Described section; Identification number: see Table

TEXTURE SYMBOL



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	K	Kame
E	Esker	LB	Lacustrine Beach
EM	End Moraine	LD	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	LP	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	WD	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.

Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: C. P. Gravenor, 1954a, b, 1957.

Additional Fieldwork by: Staff of the Aggregate Assessment Office.

Compilation and Drafting by: Staff of the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 96.

This map is published with the permission of V. G. Milne, Director, Ontario Geological Survey.

Issued 1985.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.

COUNTY OF PETERBOROUGH
PETERBOROUGH
SMITH TP
NORTH MONAGHAN TP
EMILY TP
CAVAN TP
COUNTY OF VICTORIA
COUNTY OF PETERBOROUGH
ANTHONY
HILL
CAVAN TP
MANVERS TP
NORTH MONAGHAN TP
CAVAN TP
NORTH MONAGHAN TP
OTONABEE TP
Mount Pleasant
Fairmount
Springville
Ida
Cavan
Kendrick Creek
Peterborough Airport
CANADIAN PACIFIC
Hospital
Sewage Lagoon
Race Track
Drive-in theatre
Cemetery
Auto Wreckers
Concrete Plant
Under Construction
Dam
Motel
Golf Course
Shopping Centre
Park
Ditch
Creek
Jackson
TRENT
2 Lines
1023
932
TA 115

PETERBOROUGH

SMITH TP

NORTH MONAGHAN TP

EMILY TP

CAVAN TP

COUNTY OF PETERBOROUGH

NORTH MONAGHAN TP

CAVAN TP

NORTH MONAGHAN TP

OTONABEE TP

Springville

Fairmount

Ida

Cavan Sta

Peterborough Airport

Little Lake

Trent Canal

CANADIAN PACIFIC

Golf Course

Race Track

Drive-in-theatre

Sewage Lagoon

Sewage Disposal Plant

Concrete Plant

Auto Wreckers

Shopping Centre

Hospital

Cemetery

Dam

Under Construction

City Limits

Location

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Ministry of Northern Affairs and Mines

Ontario

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

CAVAN, NORTH MONAGHAN and SOUTH MONAGHAN TOWNSHIPS

COUNTY OF PETERBOROUGH

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 31 D/1, 31D/2
31 D/7, 31D/8

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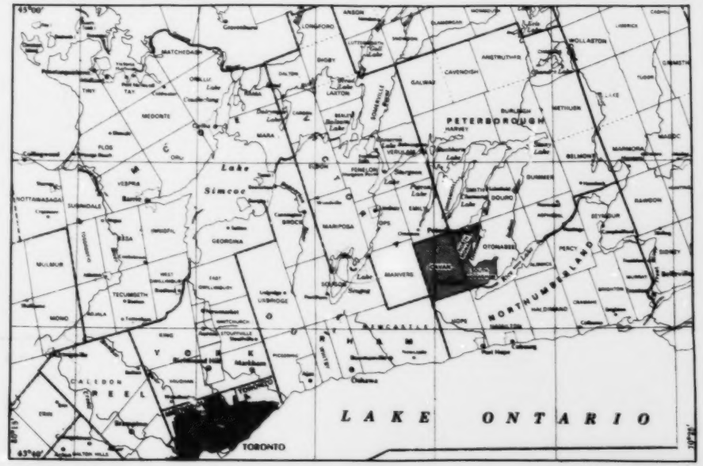

Location Map

Scale 1:1,800,000

SYMBOLS

(Some symbols may not apply to this map.)

— — — — Geological and aggregate thickness boundary.

•••••••••••••••••• Buried geological and aggregate thickness boundary.

COUNTY OF VICTORIA
COUNTY OF PETERBOROUGH
CAVAN TP
MANVERS TP
ANTHONY HILL
Mount Pleasant
Fairmount
Springville
NORTH MONAGHAN TP
CAVAN TP
OTONABEE TP
NORTH MONAGHAN TP
Ida
Cemetery
COUNTY OF PETERBOROUGH
COUNTY OF VICTORIA
Auto Wreckers
Kendrick Creek
Peterborough Airport
Under Construction
Dam
CANADIAN PACIFIC
Cavan Sta
Cavan
Fraserville
COUNTY OF PETERBOROUGH
SOUTH MONAGHAN TP
Wallace Point
Abandoned
Pranoel Sta
Cavan
Millbrook
Sports Track
MANVERS TP
South Monaghan
SOUTH MONAGHAN TP
CAVAN TP
Baillieboro
Baxter
BM 697
BM 884
2 Lines
Race Track
Drive-in theatre
Cemetery
Sdg
GP
Pit
Dugout
Ball Grounds

© OMNAM-06

Location Map

Base map by
sources.
Licence data
Resources
Aggregate su
Ministry o

Geology by:

Additional F

Compilation
Ontario G

This map is t

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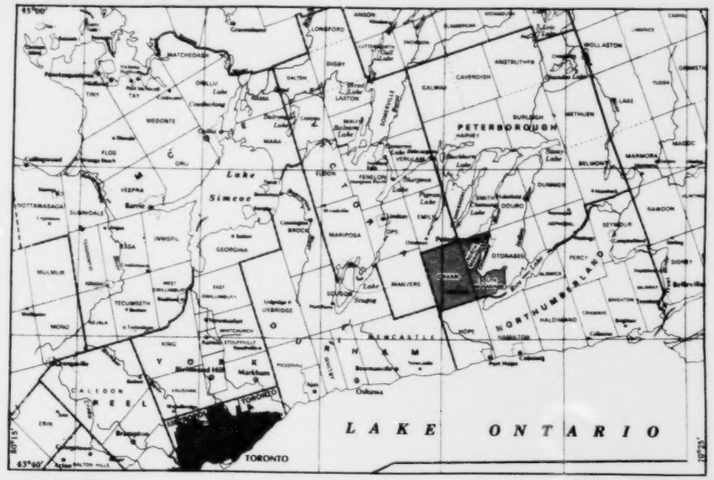

Location Map

Scale 1:1,800,000

SYMBOLS

(Some symbols may not apply to this map.)

- Geological and aggregate thickness boundary.
- Buried geological and aggregate thickness boundary.
- Municipal boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 — Licenced property boundary; Property number: see Table 2.
- 3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
  *Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

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This map is to accompany O.G.S. Aggregate Resources Inventory Paper 96.

Millbrook

Dranoel Sta

Carmel

Glamorgan

South Monaghan

Bailieboro

Wallace Point

Sports Track

Abandoned

Baxter

Cavan

Squirrel

MANVERS TP

CAVAN TP

NEWCASTLE TP

HOPE TP

SOUTH MONAGHAN TP

COUNTY OF PETERBOROUGH

COUNTY OF NORTHUMBERLAND

CAVAN
NORTH MONAGHAN
SOUTH MONAGHAN

CAVAN
NORTH MONAGHAN
SOUTH MONAGHAN

Selected sand and gravel resource area; Secondary significance.

Selected sand and gravel resource area; Tertiary significance.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
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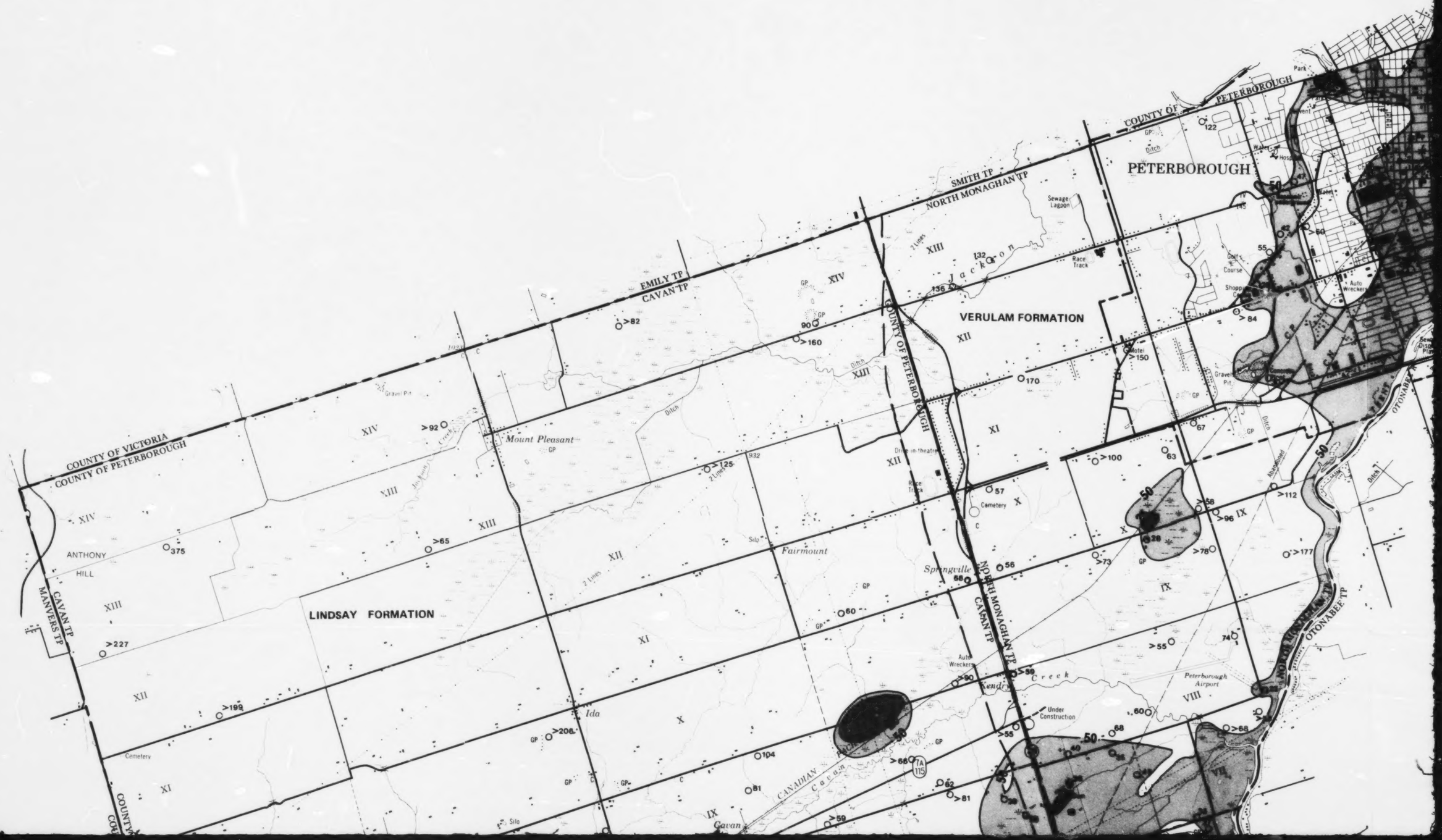
COUNTY OF PETERBOROUGH
PETERBOROUGH
SMITH TP
NORTH MONAGHAN TP
EMILY TP
CAVAN TP
COUNTY OF VICTORIA
COUNTY OF PETERBOROUGH
ANTHONY HILL
MANVERS TP
CAVAN TP
NORTH MONAGHAN TP
CAVAN TP
OTONABEE TP
VERULAM FORMATION
LINDSAY FORMATION
Mount Pleasant
Fairmount
Springville
Ida
Cavan
Kendrick Creek
Peterborough Airport
Sewage Lagoon
Race Track
Drive-in-theatre
Auto Wreckers
Golf Course
Shopping Centre
Motel
Hospital
Cemetery
Gravel Pit
Silo
Ditch
Under Construction
CANADIAN Canal
Jackson
Park
GP
2 Lines
7A
115

PETERBOROUGH

VERULAM FORMATION

EMILY TP
CAVAN TP
SMITH TP
NORTH MONAGHAN TP
COUNTY OF PETERBOROUGH
OTONABEE TP
CAVAN TP
NORTH MONAGHAN TP
OTONABEE TP

Jackson Creek
Ida
Fairmount
Springville
Peterborough Airport
Little Lake
Sewage Lagoon
Race Track
Golf Course
Auto Wreckers
Sewage Disposal Plant
City Limits
Cemetery
Drive-in theatre
Under Construction
Gravel Pit
Motel
Park
Trailer Park
Ditch
Hospital
Shopping Centre
CANADIAN NATIONAL RAILWAYS
CANADIAN PACIFIC RAILWAYS

CA

PA

Ministry of Northern Affairs and Mines

Ontario

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

CAVAN, NORTH MONAGHAN and SOUTH MONAGHAN TOWNSHIPS

COUNTY OF PETERBOROUGH

MAP 3
BEDROCK RESOURCES

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 31 D/1, 31D/2
31 D/7, 31D/8

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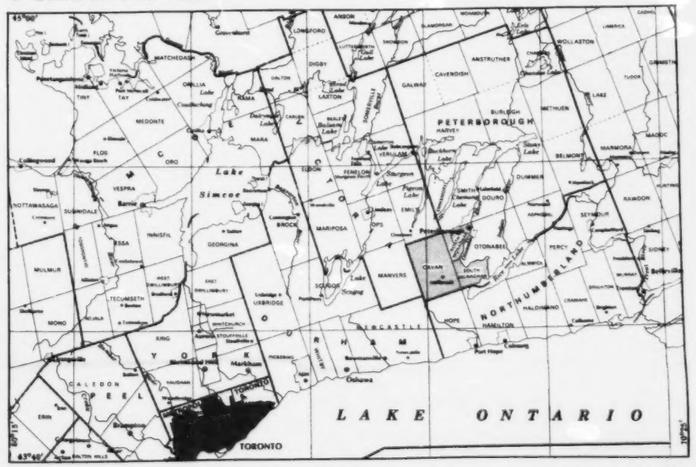


Location Map

Scale: 1:800,000

LEGEND

PALEOZOIC

ORDOVICIAN

UPPER ORDOVICIAN

LINDSAY FORMATION

SYMBOLS

(Some symbols may not apply to this map.)

— — — — Geological formation boundary.

– – – – – – Geological formation member boundary.

—•—•— Formation thickness boundary (see text).

25 Drift thickness contour 25 feet (8 m) interval

COUNTY OF VICTORIA
COUNTY OF PETERBOROUGH
ANTHONY HILL
MANVERS TP
CAVAN TP
LINDSAY FORMATION
Mount Pleasant
Fairmount
Springville
NORTH MONAGHAN TP
OTONABEE TP
Ida
Cavan Sta
Cavan
Dranoel Sta
Millbrook
Penitentiary
Fair Grounds
Peterborough Airport
Fraserville
Wallace Point
South Monaghan
Bailieboro
Kendrick Creek
Baxter Creek
Abandoned
Gravel Pit
Cemetery
Auto Wreckers
Drive-in theatre
Under Construction
Sports Track
Dugout
Dam
BM 697
BM 894
GP
Sta
2 Lines
7A
115

LINDSAY FORMATION

VERULAM FORMATION

LINDSAY FORMATION

Fairmount

Springville

Peterborough Airport

Fraserville

Bensfort Bridge

Bensfort Corners

Wallace Point

Millbrook

South Monaghan

Bailieboro

Hall Landing

Rice Lake

Cow Island

Long Island

Jubilee Point

Gravel Pit

Wharf Marina

Submarine Cable

Fair Grounds

Cemetery

Auto Wreckers

Under Construction

Drive-in theatre

Sawmill

Dugout

Abandoned

Baxter Creek

Kendi... Creek

Steamboat Ck

Ditch

Dam

Sta

Cavan Sta

CANADIAN

TRENT CANAL

RIVER

NORTH MONAGHAN TP

CAVAN TP

SOUTH MONAGHAN TP

OTONABEE TP

COUNTY OF PETERBOROUGH

HAMILTON TP

TA 115

LEGE

PALEOZOIC

ORDOVICIAN

UPPER

LIN

L

MIDDL

VE

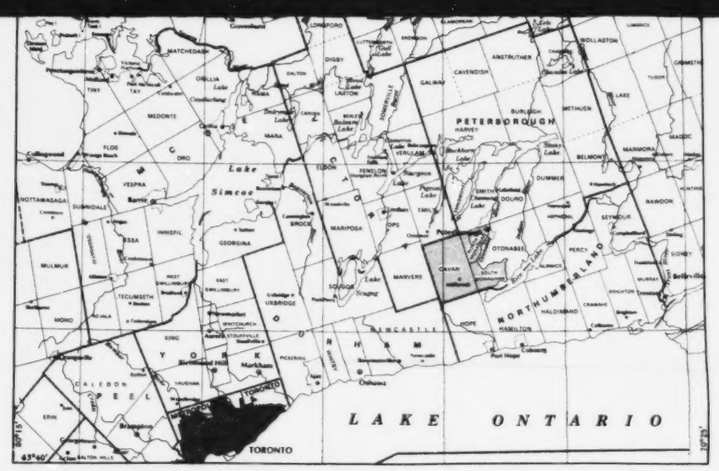
Base map by Surveys and Mapping Bra
sources.

Licence data from District and Regiona
Resources.

Aggregate suitability data from the E
Ministry of Transportation and Comm

Selected drilled water well data from the

Drilling data from the Petroleum Res
Natural Resources.



Location Map

Scale: 1:800,000

LEGEND

PALEOZOIC

ORDOVICIAN

UPPER ORDOVICIAN

LINDSAY FORMATION
Limestone and shale

MIDDLE ORDOVICIAN

VERULAM FORMATION
Limestone

SYMBOLS

(Some symbols may not apply to this map.)

- Geological formation boundary.
- Geological formation member boundary.
- Formation thickness boundary (see text).
- 25 — Drift thickness contour: 25 foot (8 m) interval.
- Municipal boundary.
- (2) — Selected bedrock resource area; Deposit number: see Table 6.
- Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.
- Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 to 15 m) of overburden: see Table 4.
- x — Isolated bedrock outcrop.
- Q2 — Licenced quarry boundary; Property number: see Table 5.
- Q3 — Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
- O 28 — Selected drilled waterwell location; reported depth to bedrock (in feet).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: D. M. Carson, 1980a,b.
B.A. Liberty, 1969.

Compilation and Drafting by: Staff of the Aggregate Assessment Office Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.
This map is to accompany O.G.S. Aggregate Resources Inventory Paper 96.

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LINDSAY FORMATION
LINDSAY FORMATION
Millbrook
Penitentiary
Fair Grounds
Dranoel Sta
Bailieboro
South Monaghan
Carmel
Glamorgan
Wallace Point
PETERBOROUGH CO.
MANVERS TP
CAVAN TP
SOUTH MONAGHAN TP
NEWCASTLE TP
HOPE TP
COUNTY OF PETERBOROUGH
COUNTY OF NORTHUMBERLAND
Cavan Creek
Baxter Creek
Squirrel Creek
Abandoned
Gravel Pit
Sports Track
Kilns
Dam
Sawmill
GP
BM 897
BM 894
2 Lines

Base map by Surveys and Mapping Branch, Onta
sources.

Licence data from District and Regional Offices,
Resources.

Aggregate suitability data from the Engineering
Ministry of Transportation and Communication

Selected drilled water well data from the Ontario M

Drilling data from the Petroleum Resources Se
Natural Resources.

CAVAN

NORTH MONAGHAN

SOUTH MONAGHAN

CAVAN
NORTH MONAGHAN
SOUTH MONAGHAN

Limestone

see Table 6.

Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.

Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.

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